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University of Toronto, Toronto.

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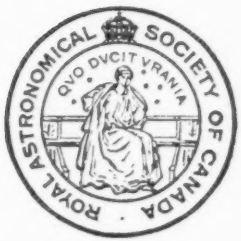

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THE JOURNAL
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Vol. XXVIII, No. 7 SEPTEMBER, 1934 Whole No 236

A MECHANICAL METHOD OF REDUCING RADIAL VELOCITIES TO THE SUN

By WILLIAM H. CHRISTIE

ALTHOUGH the necessary computations for reducing radial velocities to the sun have been greatly simplified by the use of tables, such as those of Campbell,[1] and by the latitude and longitude tables of Young, unfortunately as yet unpublished, and also by the graphical methods of Henroteau[2] and Van Biesbroeck,[3] the latter a most elegant solution, there is still room for improvement and simplification.

The following method, which has been developed by the writer, solves the fundamental equation

$$v_a = V_a \sin (\odot - i - \lambda) \cos \beta$$

in but a few seconds. The data necessary for the solution, which are the right ascension and declination of the star and the date of observation, may be taken directly from the observing book; no auxiliary tables or interpolations are necessary.

Let Fig. 1 represent the equatorial coordinate system of the celestial sphere projected upon the plane of the ecliptic, the poles of the ecliptic and equator being at P and P' respectively. Let S be the projection of any star upon this plane and H the position of the sun, minus the small angle i. If λ be the star's longitude, $\odot$ the longitude of the sun and r the radius of the sphere, we have

[1] *Stellar Motions*, p. 68.
[2] *Pop. Astr.*, vol. 33, p. 248, 1925.
[3] *Ap. J.*, vol. 64, p. 258, 1931.

$$\Upsilon \triangleq H = (\odot - i)$$

and $$\Upsilon S' = \lambda$$

Then $$(\odot - i - \lambda) = S' \triangleq H$$

and $$\sin(\odot - i - \lambda) = -\cos S'T$$

$$= -\frac{PR}{r}$$

Now $$\cos\beta = \frac{PS}{r}$$

hence $$\sin(\odot - i - \lambda)\cos\beta = -\frac{PQ}{r} = -\frac{P''S}{r}$$

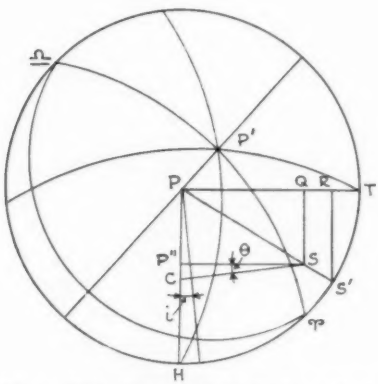

Fig. 1. Illustrating method of reduction to the sun.

The required velocity will therefore be

$$v_a = -V_a\left(\frac{P''S}{r}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Now let

$$V_a = V_{a(\min)} \sec\theta$$

where $V_{a(\min)}$ is the velocity of the earth in its orbit at apogee. Substituting this value of V_a in (1), we have

$$v_a = -V_{a(\min)}\frac{P''S}{r}\sec\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Let the units of measurement be so chosen that

$$r = V_{a(\min)},$$

then from (2) we have

$$v_a = -P''S \sec \theta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Hence, if the scale, CS, with which $P''S$ is measured makes an angle θ with $P''S$,

$$P''S = \frac{CS}{\sec \theta}$$

whence, from (3), we have, finally

$$v_a = -CS$$

The values for V_a, i and θ are given in the accompanying table.

THE EARTH'S ORBITAL VELOCITY V_a AND THE DEVIATION i WHEN THE SUN'S LONGITUDE IS ⊙

⊙	$V_a$km./sec.	i	θ	⊙	$V_a$km./sec.	i	θ
0°	29.87	+56′.3	11°.5	180°	29.68	−56′.7	9°.5
10	29.78	+57.5	10.6	190	29.76	−57.6	10.4
20	29.70	+57.0	9.8	200	29.85	−56.8	11.3
30	29.61	+54.8	8.7	210	29.93	−54.2	12.1
40	29.53	+50.8	7.6	220	30.01	−50.1	12.7
50	29.46	+45.4	6.5	230	30.08	−44.4	13.3
60	29.40	+38.4	5.4	240	30.14	−37.5	13.8
70	29.34	+30.3	4.0	250	30.20	−29.4	14.3
80	29.36	+21.2	2.5	260	30.24	−20.5	14.5
90	29.28	+11.4	1.4	270	30.26	−11.0	14.7
100	29.27	+ 1.2	0.0	280	30.27	− 1.2	14.8
110	29.28	− 8.9	1.4	290	30.26	+ 8.6	14.7
120	29.30	−18.8	2.5	300	30.24	+18.2	14.5
130	29.33	−28.1	3.6	310	30.21	+27.3	14.4
140	29.38	−36.5	5.0	320	30.16	+35.6	14.0
150	29.44	−43.8	6.2	330	30.10	+42.8	13.5
160	29.51	−49.7	7.3	340	30.03	+48.8	12.9
170	29.59	−54.0	8.4	350	29.95	+53.4	12.2
180	29.68	−56.7	9.5	360	29.87	+56.3	11.5

The device constructed by the Observatory consists of a circular disc, 42 inches in diameter free to rotate about its centre, and mounted on a supporting frame which is hung upon a wall at a convenient height. The equatorial coordinates for every ten minutes in right ascension and every degree in declination are pro-

jected upon this disc, the diameter of the projection being 40 inches. By the judicious use of coloured inks the coordinates may be made readily distinguishable, greatly facilitating the location of a point. For instance, in our projection all hour circles are in black and the intermediate ten-minute circles in red. Every ten degrees in declination is in black, the intermediate five degree circles in blue and the remaining degrees in green.

Surrounding the projection are two scales: a $(\odot - i)$ scale and a longitude scale. The former is obtained by subtracting the quan-

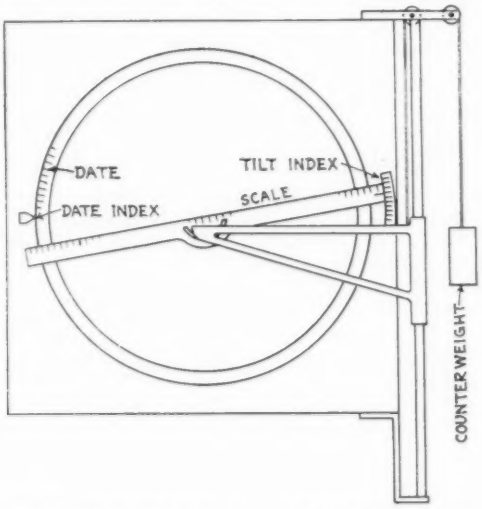

Fig. 2. Mechanical device for reducing radial velocities to the sun.

tity i from the longitude of the sun, as given in the Nautical Almanac, and is graduated into months and days. For the sake of convenience the zero point of this scale has been shifted counterclockwise ninety degrees.

On the right-hand side of the supporting frame (see Fig. 2) is a vertical metal bar on which a close fitting tube is free to slide. To the tube is attached a rigid arm which supports the velocity scale attached to it by means of a circular arc, the centre of which coin-

cides with the zero on the edge of the scale. The arc slides between gibs in order that the tilt of the scale may be adjusted to the angle θ, which can be read from a suitable scale graduated into months, the days being estimated. The whole of the sliding mechanism is supported by a flexible cable which passes over two small pulleys at the top of the frame and down to a counterweight. The vertical rod is accurately adjusted so that the zero passes through the centre of the projection when the scale is raised or lowered. On the left side of the frame is a date index. This is adjusted so that when the $(\odot - i)$ coincides with the zero on the velocity scale, the latter being at the bottom of the projection, the index reads to the date. It will be seen that local time may be used as readily as that of any other meridian. Once set, the date index is changed only at the end of the year, when it is moved forward from Dec. 32 to Jan. 1, or in leap years, when it must be shifted backward one day following February 28.

To make a sun reduction the disc is turned to the date, the hour being estimated; the tilt of the velocity scale adjusted; the position of the star is then plotted and the scale raised until its edge coincides with the star; the velocity is then read off. The sign of the correction will be positive if the star is to the left of the zero, negative if to the right. If the star is south of the ecliptic, 12^h is added to the right ascension and the sign of the declination changed, the sign of the velocity will then be changed. It will be seen that the tilt of the scale needs to be adjusted only about once a week, at the maximum rate of change, and the disc turned only every three hours, when working to the nearest tenth of a kilometer.

In actual practice it takes about twenty seconds to plot the position of a star and read off the sun reduction. The precision is dependent upon the accuracy with which the stars are plotted and this depends, in turn, upon the accuracy of the projection; the mechanical errors are negligible. The present projection, which is the work of the writer, is not perfect but gives fairly satisfactory results, even at the edge, where the inaccuracies are greatest. The precision north or south of 20° latitude is to the nearest tenth of a kilometer per second. On the ecliptic, when the sun and star's longitude differ by 180°, errors of as much as 0.4 km/sec. are encountered in the regions of longitude 0° and 180°. These errors

are not serious and would not occur with an accurate projection, and since this projection was of an experimental nature the results are quite satisfactory; later we hope to replace it with a better one.

To draw the large number of ellipses needed for the projection would be a laborious undertaking, were they made by the usual projective methods. In order to reduce the labour to a minimum, the writer devised an ellipsograph capable of drawing any ellipse with a major axis of forty inches or less. This instrument will be described in a future publication of this Observatory.

Carnegie Institution of Washington
Mount Wilson Observatory,
April, 1934.

NOCTILUCENT CLOUDS

By E. H. Vestine

(*Continued from page 272*)

V. Some Statistical Considerations Respecting Occurrences of Noctilucent Clouds During 1885-1933

The foregoing list represents what has been observed of the true distribution of occurrences of noctilucent clouds. For statistical purposes it thus represents a sample from population.

In Fig. 4 the total number of years in which the clouds were

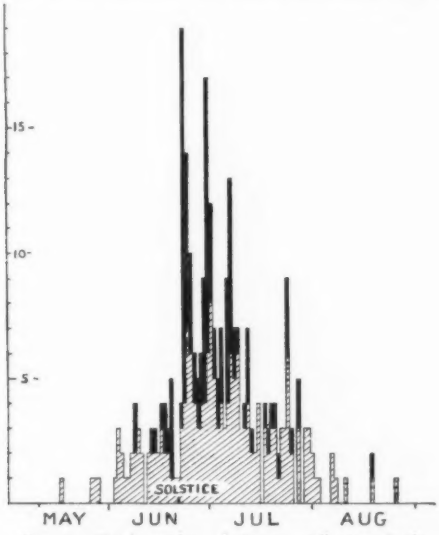

Fig. 4. Total number of times noctilucent clouds have occurred on a given date during the summers of the years 1885-1933. (hatched histogram). Total number of observations of noctilucent clouds on a given date during the summers of the years 1885-1933. (blocked histogram).

observed on a particular date during summers of the years 1885-1933 is represented by the hatched histogram. The favoured dates increase to a maximum some days after the solstice and then diminish.

In many cases, when the displays were brighter or more extensive, the clouds were seen on the same evening by several observers in different parts of Europe. The blocked histogram represents

the total number of times observations were made on the clouds on a particular date during the years 1885-1933. This distribution then may with caution be taken to indicate something of the manner in which the brilliance or extent of the displays varied relative to the summer solstice.

In Fig. 5 these frequencies have been smoothed according to the formula $f=(A+2B+C)/4$, where B is the frequency on the date in question and A and C the frequencies on adjoining days. This serves to correct at least partially for cloudy nights and other

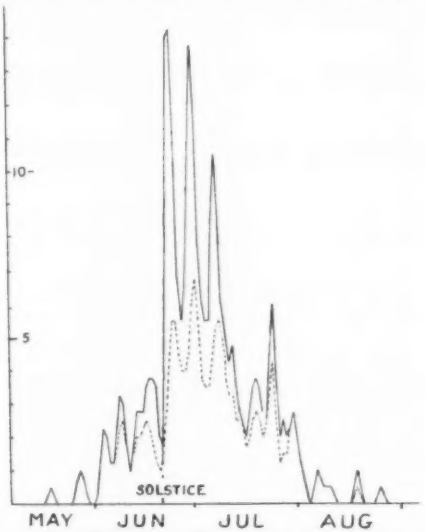

Fig. 5. The data of Fig. 4 smoothed according to frequency $f=(A+2B+C)/4$

factors. These smoothed distributions should thus represent the actual relative frequencies with greater accuracy than the histograms. In Figs. 6 and 7, cloud movements are indicated

In the following table the variates $x = 1, 2, \ldots$ represent the intervals May 15-19, May 20-24, . . . and for each year the number of evenings on which the clouds occurred out of a possible five are given. The row f gives the total for each interval during these years. In the row $4f_1$, f_1 is the relative frequency total for each five-day period, the smoothing, however, being applied to daily

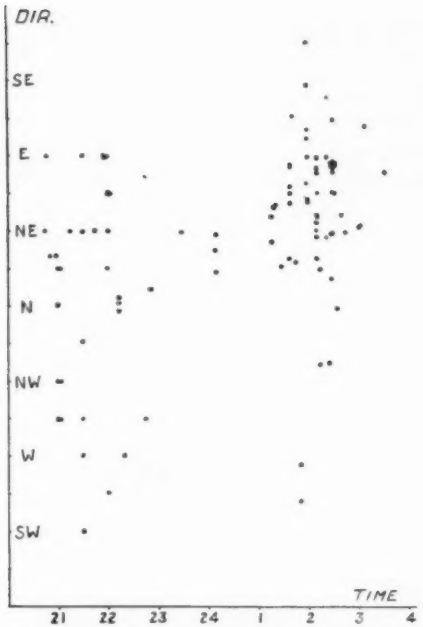

Fig. 6. Direction of movement of noctilucent clouds for various values of approximate local time.

totals. In the next row f', the total number of observations is given.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Sum
1885	.	.	.	.	1	1	.	1	3	3	3	1	1	4	1	1	.	.	.	.	.	20
1886	.	.	1	2	2	2	2	2	3	3	2	3	1	1	3	3	.	1	.	.	.	31
1887	.	.	.	.	2	2	5	4	5	4	3	1	4	3	2	3	.	.	.	.	.	38
1888	.	.	.	1	1	1	1	2	3	1	3	.	1	2	.	.	.	.	.	.	.	16
1889	.	.	.	.	1	1	.	1	.	1	.	1	.	.	1	2	.	.	.	1	.	9
1890	.	.	1	.	.	.	1	.	1	1	2	3	1	.	1	.	.	.	.	.	.	11
1891	.	.	.	1	1	1	.	.	1	1	.	2	.	.	.	.	.	.	.	.	.	7
1892	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	4
1893	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	3
1894	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2
1899	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
1903	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
1906	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
1908	.	.	1	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	5
1909	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
1910	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	2
1911	.	.	.	.	.	.	.	.	5	5	5	3	2	.	.	.	.	.	.	.	.	20
1914	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	3
1916	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1920	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1932	.	.	.	.	.	.	.	.	.	1	1	2	.	1	1	.	.	1	.	.	.	7

1933.	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	1	..	..	..	..	3
f	1	0	3	4	8	9	11	10	24	26	22	18	11	13	11	10	2	2	0	1	1	187
$4f_1$	4	0	12	15	34	35	43	43	94	105	88	71	45	54	44	36	10	7	1	3	4	748
f'	1	0	3	4	10	10	16	30	41	50	39	23	13	16	17	10	2	2	0	2	1	290
$4f''$	4	0	12	15	34	35	48	43	93	90	88	71	45	54	44	36	10	7	1	3	4	732
f_c	0.5	1.1	2.1	3.7	6.0	9.0	12.5	16.0	18.8	20.4	20.5	18.9	16.2	12.8	9.3	6.3	3.9	2.2	1.2	0.6	0.3	

Since the clouds which are observed on any particular night are usually observed on several successive nights, for purposes of curve-fitting the smoothed data given in the broken curve in Fig. 5 have

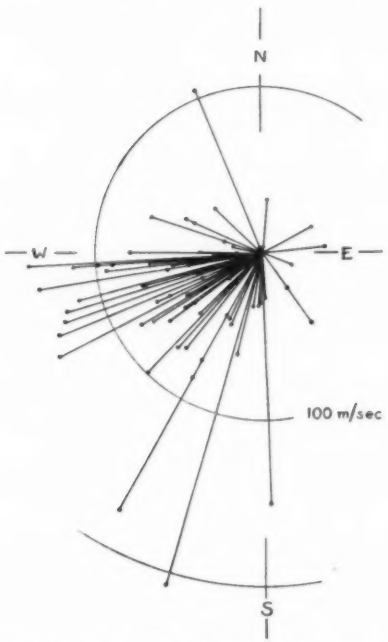

Fig. 7. The vectorial distribution of velocities of noctilucent clouds moving from various azimuths.

been totalled arbitrarily in 5-day intervals, excluding, however, the four evenings of occurrence ascribed to the great Siberian meteor, as resulting from a very particular and unusual cause. This gives the values in row $4f''$, where f'' is the relative frequency. The constants for the distribution are as follows:

$$\text{Mean } \bar{x} = \frac{\Sigma f'' x}{\Sigma f''} = 10.54$$

$$\text{Standard deviation } \sigma = \sqrt{\overline{(x-\bar{x})^2}} = 3.53$$

$$\text{Measure of skew } a_3 = \overline{\left(\frac{x-\bar{x}}{\sigma}\right)^3} = 0.04$$

$$\text{Measure of flatness } a_4 = \overline{\left(\frac{x-\bar{x}}{\sigma}\right)^4} = 2.90$$

$$J = 3a_3^2 - 2a_4 + 6 = 0.21$$

where J is a criterion for the choice of curves as given in Pearson's "Tables for Statisticians and Biometricians". Since for a normal error curve $a_3 = 0$, $a_4 = 3$, and $J = 0$, a normal error curve given by

$$f = \frac{1}{\sqrt{2\pi}} \frac{183}{3.53} e^{-\frac{1}{2}\left(\frac{x-10.54}{3.53}\right)^2}$$

was fitted to the distribution. The theoretical frequencies are given in the row f_c. Then

$$\chi^2 = \Sigma \frac{(f''-f_c)^2}{f_c} = 12.64,$$

so that in nine cases out of ten, random samples would be expected to give a fit as bad as, or worse than, that obtained for this particular sample. It is to be noted here that the largest discrepancy occurs at interval 21 at the extremity of the curve where the display of August 25, 1916, obtains placement. As has been indicated in the summary there may be some doubt as to the authenticity of this display, which view is further supported by the size of the standard deviation for the distribution. Thus the probability stated above may actually be greater than 0.9, which is in any case so high that it may be concluded that a normal error curve describes excellently the distribution of evenings of occurrence of noctilucent clouds during summer months (Fig. 8).

It has been considered superfluous here to calculate the probability that the lag after the solstice be unreal as the mean variate $\bar{x}$ for each of the twenty-two years also falls after the time of the solstice.

If the chance of observing the clouds were dependent only on the duration of evening twilight the clouds should have been reported with greatest frequency at the time of the solstice rather than about twelve days later. Thus, although it is possible that observers were more observant after having seen the clouds on an earlier occasion during the summer, it appears that the duration of evening twilight is a factor of secondary importance in their observation. This is corroborated by the absence of observations by

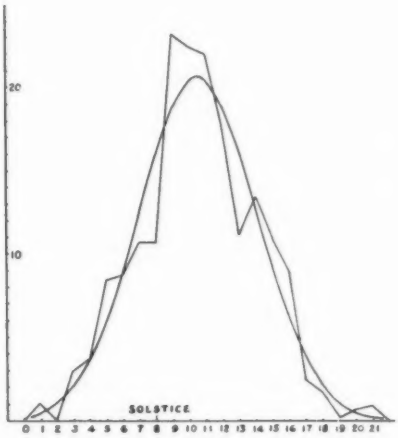

Fig. 8. Total number of times noctilucent clouds have occurred during 5 day intervals, interval 8 being centred on the solstice, totalled for the years 1885-1933, fitted with normal error curve.

expeditions in arctic and antarctic regions, where the sun remains within the proper range of negative altitudes for a considerable length of time near the winter solstice. Near the summer solstice such observers, of course, would be unable to see the clouds owing to insufficient contrast. These considerations along with the absence of observations shortly after sunset and before sunrise in tropical regions lead to the conclusion that the phenomenon is confined mainly to high latitudes.

VI. The Origin of Noctilucent Clouds

The origin of the clouds is uncertain. Jesse, who has contributed most to our knowledge of them, sums up his work with the conclusion that they are due to the presence of foreign matter at a height of about 82 km. above the earth. He suggests that this matter may be due to the condensation of gases hurled there by volcanic explosions. Wegener,[11] Jardetzsky, [12] and Vegard [13] have attempted to explain them as composed of ice crystals.

While an ice crystal theory is inviting, its success is largely dependent on temperature. At 80 km. an atmospheric pressure of the order of 0.03 mm. of mercury is to be expected, and low temperatures would be necessary to permit the formation of ice crystals. Humphreys,[14] assuming a value for the concentration of the water vapour at this level, obtains a temperature of 160°A. as necessary. Such a temperature is unlikely in view of recent evidence for higher temperatures furnished by sound explosion experiments, [15 16] calculations on the ozone layer,[17] meteors, helium content of the atmosphere,[18 19] the half width of the green line of the night sky, and comparisons on nitrogen bands in the auroral spectrum.[20] It appears that a temperature more of the order of 300°A may be expected at 80 km., but there are some individual weaknesses in the evidence[21] so that the present data are not sufficient to throw out the hypothesis that the clouds are to be attributed to ice crystals in entirety.

Data on meteoric clouds have been collected by Malsch,[22] who along with Backhouse suggests a meteoric origin for the phenomenon. Gutenberg[16] has proposed a dust origin.

On the morning of June 30, 1908, a huge mass of meteoric fragments, estimated to weigh 40,000 tons, struck the earth in northern Siberia at about 101°E. longitude and 60°N. latitude.[23] Appearances of luminosity similar to those exhibited in noctilucent clouds are said to have been seen on June 29, while on June 30 an extraordinarily brilliant display was described by a large number of observers in Siberia, Russia, Denmark and Germany.[24] The display as seen by observers in Russia extended from 45° to 60°N. latitude and 23° to 48°E. longitude and extended as far west as Bristol. Busch identifies the brilliant display as seen at Arnsberg as exactly

similar to the noctilucent clouds of 1885, and from a measurement of their highest point of illumination deduces a least possible height of 52 km. Only one-third of the observers in Russia who saw the display on June 30 reported the weaker display of July 1. There were weak traces also on July 2. While it seems probable that part of the luminosity may have been due to meteoric cloud or dust material in the atmosphere there does not appear to be any real reason for doubting that a portion of the display at least must be ascribed to noctilucent clouds, caused by the great Siberian meteor.

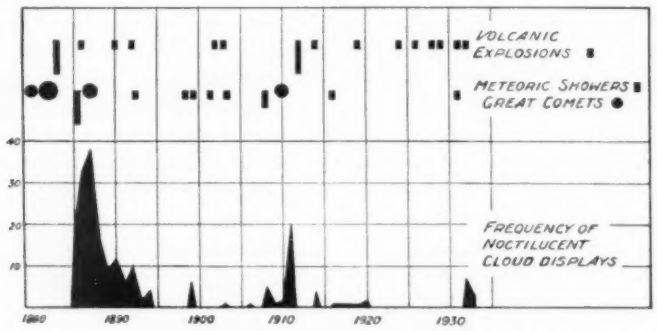

Fig. 9. Yearly frequency of occurrence of noctilucent clouds compared with yearly appearances of volcanic explosions, great comets and meteoric showers.

In Fig. 9 an attempt has been made to compare the yearly totals of evening appearances of noctilucent clouds for the years 1885-1933 with the yearly times of explosive volcanic eruptions and striking cosmic phenomena in the form of great comets and meteor showers.

The years in which explosive volcanic eruptions threw an appreciable amount of volcanic material well into the atmosphere is based on Humphreys' "Physics of the Air" for the years 1880-1912 and on "The Volcano Letter" for the years 1913-1933.

Volcanic Explosions, 1913-1933:

1914—Sakurajima, Komagadake.
1919—Komagadake.
1924—Komagadake.
1926—Tokachi, Sentorin.

1929—Asama (two major explosions, one throwing out an estimated amount of 3.4 million cubic meters of dust).
1931—Gorely (Kamchatka).
—Kluchevokaya, March 25-27, 120 million cubic meters of ash.
—Aniakchak, May 1 (Aleutian).
1932—Mount Cleveland, January 1 (Aleutian).
—Shishaldin, February (Aleutian).
—Kluchevakaya, January to February (Kamchatka).
—Quizopú, April (South America).

Comets:

The Great Comets of 1880, 1882 and 1887; Halley's Comet of 1910.

In Olivier's "Meteors" the following data are given regarding meteoric showers for the years 1880-1926.[23]

Meteors:

1885—Nov. 27, Bielids, 600 to 1,000 per minute.
1892—Nov. 23, Bielids, 6 per minute.
Nov. 27, Bielids, large fall in Mexico.
1889—Nov. 24, Bielids, 2 to 3 per minute.
1898—Nov. 14, Leonids, weak, 800 at Harvard.
1899—Nov. 14, Leonids, cloudy, 14 seen.
1901—Nov. 14, Leonids, 225-800 per hour.
1902—Nov. 14, Leonids, poor.
1903—Nov. 14, Leonids, a fair return.
1908—June 30, 00.15 G.M.T., great Siberian meteor.
1916—June 28, Pons-Winnecke comet meteors, a short brilliant shower lasting only a few hours.

The Perseids appear for several weeks each year with a maximum about August 10 and are quite numerous from August 5 to 15. From August 10 to 13 one is certain to see large numbers of them. Halley's comet and Lyrid meteors are very few in number.

The period 1885-1894 was particularly rich in displays of noctilucent clouds which were brightest in 1885-1886 and diminished in brilliance and frequency to 1894. Writers have stated that the displays of this period were due to the explosion of Krakatoa in 1883. However, the period 1880-1887 is one in which the most marked and striking number of near cosmic appearances in the form of frequent meteor falls, meteoric showers and great comets of the past half century occurred. Three of the famous group of the Great Comets 1880, 1882 and 1887 appeared following a similar orbit. Comet 1882 (III) was one of the finest on record, and while

passing very close to the sun broke into four parts, so that no doubt large quantities of cosmic material would be left by it within the space of the solar system.

The clouds of 1899 would be attributed rather to cosmic than volcanic sources. The clouds of 1908-1911 are not attributable to volcanic sources so that a cosmic origin seems indicated.

In 1912 an eruption quite comparable with Krakatoa, that of Katmai, in Alaska, took place, but no marked increase in the frequency of noctilucent clouds is indicated.

An increase in frequency of the clouds is noted in 1932-1933 following a period of a considerable number of minor volcanic explosions. There is little in the way of cosmic appearances that may be associated with the appearance of the clouds unless it be the closer approach to the more concentrated portion of the orbit of the Leonids.

In forming any conclusions from the comparisons it is evident that, whereas the times of occurrence of explosive volcanic activity are comparatively well known, those for cosmic phenomena that may have been associated with the appearance of the displays are not necessarily completely represented. In the comparison we are assuming also that volcanic material can find its way up to as great a height as 80 km. and remain at least this high for several years, which must be considered doubtful. On the other hand, it is definitely known that cosmic material does appear at such heights, as is shown in the case of meteoric phenomena. It appears, also, that there has been a marked increase in the frequency of noctilucent clouds whenever marked cosmic phenomena have been manifested, whereas this has not always been the case with times of occurrence of volcanic explosions. Although the justification of some features of this comparison are subject to criticism, the comparison favours a cosmic rather than a volcanic origin.

The correlation with sunspot numbers is not entirely satisfactory with the data available at present. The times of greatest frequency as shown in the data collected here are near a sunspot minimum, as shown for the clouds of 1887, 1899, 1911 and 1932.

It seems that there are several possible sources of the cosmic material which may be associated with the formation of noctilucent

clouds. Retardation of the motions of comets at times in their passage around the sun is thought by some astronomers to be due to the existence of scattered clouds of cosmic material distributed in the space about and within the solar system. There is also the possibility that the earth may pass through the finely divided cosmic material distributed near or in the orbits of comets and meteor showers. Cosmic material may also be given out by the sun.

While the critical interpretation of the colouration of the clouds must be left to those who have specialized in the study of colour effects in the atmosphere,[25] it seems there is considerable evidence as to the order of size of the particles at the times of the observations of the past half-century. Robert von Helmholtz[8] observed the clouds through coloured filters and found that while the clouds could be seen quite well through blue filters, the light was greatly diminished by red filters. It is a significant fact that in none of the observations is there any reference to the observance of a reddish tinge on the clouds at high angular altitudes. Light from the sun which passed very close to grazing incidence with the earth would have a greater preponderance of red, owing to the scattering of the light of shorter wave-lengths in the denser portions of the atmosphere. The clouds seen closer to the earth's shadow, however, show a distinctly blue tinge so that the clouds apparently reflect little light which has passed through the troposphere, as confirmed by the measurements of Jesse[1] and Störmer[2] on the position of illuminated cloud relative to the earth's shadow. The gradations of colouration may then be attributed, with fair safety, chiefly to the effect of the intervening atmosphere between observer and cloud. The failure of the cloud particles to exhibit a reddish colouration at higher angular altitudes may then be taken to indicate a size of particles which would transmit most of the red and would scatter the blue. This suggests that the size of the particles must be somewhat smaller than that of the wave-length of red light, or the diameter of the particles may be of the order of 2×10^{-5} cm. The tendency for a greenish tinge to manifest itself at times, as well as the report of a single case of yellowish colouration at higher angular altitudes, indicates that the size of the particles probably varies but that they are in general large enough to scatter the waves of the blue and occasionally the green.

In studying the effect of light pressure near the sun on particles in space, Schwartzschild[23] has shown that the pressure is a maximum for particles of a diameter one-third that of the incident light. In tails of comets rapid movements of the matter in them away from the sun have been observed. Similar movement of particles in space, assisted near the earth by gravitation, may readily cause them to penetrate the atmosphere. Gases are also subject to radiation pressure.

One of the most interesting features of the clouds are the occurrence in them of extremely regular formations, such as those in the clouds of July 19, 1885. It is indeed remarkable that these cloud-waves should always measure 9 km. from crest to crest. The formation of billow-clouds in the troposphere has been treated with success by Helmholtz and Haurwitz,[27] and a possible explanation of the occurrence of billow-waves and rotational movements in noctilucent clouds may also be indicated in air currents above and below and parallel to the cloud layers having a relative velocity with respect to each other. In this connection it is interesting to note the evidence being accumulated by observers of meteor trains which tends to indicate that above 80 km., meteor trains move mostly to the east and below that level mostly towards western azimuths.[28] It is evident, however, that since the clouds are in a heavily ionized region very regular arrangements due to charges on the particles may result. The distribution of the amount of measured ionization at the Kennelly-Heaviside layer in summer months corresponds well with that of the distribution for the frequencies of noctilucent clouds near the solstice. The formation of these cloud arrangements is clearly an important factor in congregating the particles in sufficiently concentrated aggregations to reflect enough sunlight to be seen.

Chapman[26] has discussed the effect of the various wave-lengths of solar radiation in affecting the state of the constituents of the atmosphere at various levels and it is possible that the prolonged continuous solar radiation, above polar regions, such as experienced near the time of the summer solstice, may be a contributing factor in effecting proper chemical conditions for the formation of the clouds.

Conclusion

On the whole it may be concluded that a cosmic origin of the clouds is probable. The chief objection to postulating a volcanic origin is the hurling or transporting of volcanic material to heights as great as 80 km. and keeping this matter at least this high for a period of years. On the other hand it is known that cosmic material does appear at such heights. The occurrence of the brilliant display of noctilucent clouds at the time of fall of the great Siberian meteor may be evidence in support of a cosmic origin.

It is very probable that noctilucent clouds have been mistaken on many occasions for aurora. In the records of auroral observations for the years 1885-1888 in Canada, for instance, there is a high coincidence with the dates of occurrence of noctilucent clouds observed elsewhere. The times of observation and description are occasionally such as to indicate a possibility of a mistake in identification, but it does not appear possible to determine this with certainty.

Observations of the velocities of the clouds, particularly in the interval near midnight, would be valuable. In the event that two-station photographic facilities are not available, very useful results may be obtained by taking single-station photographs in rapid succession at intervals of less than five minutes (time exposure of about one minute for an $f/6.3$ lens), when the clouds appear greater than 10° above the horizon. The velocities can then be determined on assuming the height of clouds to be 82 km. The timing of exposures must be accurate, to the nearest second if possible. Prominent features of the landscape should be included in case stars do not appear on the photographs, and all photographs should be taken from a fixed position. The least possible heights of the clouds can also be obtained from such photographs provided the correct time is known to the nearest half-minute. When the clouds are at a low altitude longer exposures are necessary and velocity determinations are very uncertain.

Further observations in Russia and North America, as well as in south temperate regions, will serve to establish their zonal distributions and possible maximum. It hardly requires mention that a really good spectrum, and also quantitative measurements of the

polarization and photometric properties of the light, may be useful in interpreting the constitution of the atmosphere as well as the origin and nature of the clouds. It would be interesting also to verify any peculiar effects on radio reception.

In conclusion the writer wishes to express his thanks to J. Patterson, Director of the Meteorological Service of Canada; A. Thomson, the Chief Physicist; Prof. B. W. Currie of the University of Saskatchewan, and Prof. R. K. Young of the University of Toronto, for their helpful criticism and advice.

Meteorological Office, Toronto

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Errata.—P. 249, line 6, read "are of the highest" instead of "are the highest".
P. 272, last line, read Sept. 7.

ONE HUNDRED YEARS AGO*

ON 15th January, 1834, the sailing ship *Mount Stewart Elphinstone* entered Table Bay, South Africa, after a voyage of exactly three months from the time of leaving Portsmouth, England. On board was one of England's greatest astronomers and one who, in the subsequent generations of the southern hemisphere has been acclaimed their leader—Sir John Herschel, Bart., K.H., F.R.S., F.R.A.S. With him he had three reflecting telescopes, each 18 inches in aperture and of 20 feet focal length. One of these was made by his illustrious father, Sir William Herschel, another by Sir John himself under his father's guidance, and the third by himself unassisted. The year 1834 was therefore one of great moment in the history of astronomy.

In 1825, Sir John Herschel commenced a survey of the sky in the northern hemisphere, which had for its immediate object a re-examination of the nebulae, clusters and double stars discovered by his father. At the conclusion of this great work he had recorded 2,306 nebulae and clusters, of which 1,781 were identical with his father's or Messier's catalogue, and Struve's catalogue of double stars. He therefore had to his credit the discovery of 525 new objects. During the course of this work, he was awarded the gold medal of the Astronomical Society of London (later the Royal Astronomical Society), on 14th April, 1826. The esteem in which he was held is shown by the speech of the President in presenting him with the medal: "The name of Herschel, doubly connected as it thus is with the history of astronomy, can perish only with the records of science. The splendid example of the father has been emulated by the son; and you have the proud and enviable satisfaction of knowing that you will share the glory of his immortal name." The northern survey completed, it was a bold and happy decision that caused Herschel to travel to South Africa in order to survey the southern sky, and so make his observations complete.

He took up his residence, and erected his instruments, at Feldhausen, about six miles from Cape Town. So energetically did he proceed in the arranging of his instruments, that on 22nd February

*From the "Monthly Notes" of the New Zealand Astronomical Society for March, 1934.

he records, "I was able to gratify my curiosity by a view of Alpha Crucis, the nebula about Eta Argus, and some other remarkable objects, in the 20-foot reflector." On March 5th he commenced his regular course of sweeping, and on May 2nd commenced a series of double star observations, starting on Alpha Crucis. By 1838 he had viewed through these great telescopes the whole of the southern skies. He recorded positions and gave descriptions of 1,707 nebulae and clusters, as well as 2,102 double stars. Micrometrical measures of positions and estimates of magnitudes were made of the individual stars composing many star clusters. In the small area of the nebula surrounding Eta Argus alone, he measured in this manner 1,216 stars. A thorough examination was made of the Magellan Clouds, and catalogues of 919 and 244 stars, clusters and nebulae were compiled for the Greater and Lesser, respectively. In addition he made observations of the sun, the satellities of Saturn, Halley's Comet, the Milky Way, and stellar magnitudes. The devotion of this great astronomer to his work is amazing, and we are not surprised when we read in his introduction to the double star catalogue, "I will not deny that here and there, in barren and monotonous regions, an occasional entry may have been made for the homely but useful purpose of avoiding sleep (a thing not unattended with the probability of broken bones)."

It was a fortunate coincidence that ten days before Herschel arrived at the Cape, Sir Thomas Maclear, then recently appointed His Majesty's Astronomer at the Royal Observatory of the Cape of Good Hope, arrived and commenced his duties. Maclear had a difficult task ahead. He was the third astronomer appointed to the position at the Cape, and his predecessors, Fallows and Henderson, had been treated in an unkindly manner by an unsympathetic government. The stimulation he received from contact with Sir John Herschel, however, helped him considerably to overcome these difficulties with great honour. Not only did he give great assistance to Herschel by providing him with data concerning star places, but also formed a great bond of friendship with him. Writing of their association, Sir David Gill writes: "It was the brightest and most delightful period of Maclear's life; it set a stamp on the future character of his work and the policy of his directorate, and, if possible, increased his ardour as a diligent observer. To his

latest days he spoke of Sir John Herschel and his times, and of all the work and of all the fun they had together, with a racy enthusiasm but seldom met with in one beyond the years of middle life, and still more seldom in a man bereft of sight and on his last sickbed".

It was the work of Herschel that formed the basis of all our present ideas of cosmology. In the same year that he completed the survey of the southern hemisphere, 1838, Bessel, Struve and Henderson made the first measures of the distances of several stars. Later, in 1845, Lord Rosse erected his 72-inch reflector at Birr Castle, and demonstrated the fact that some nebulae had a spiral form. Commencing his researches in 1895, Easton, the Dutch amateur, was able to show before the close of the century that the galaxy must be of a spiral form, similar to the shapes disclosed in Lord Rosse's telescope.

The achievements of Sir John Herschel at this particular time are but one branch of a period of great activity taking place in the whole scientific world. The year 1834 was perhaps not marked by any such epoch-making event as the inauguration of regular steam navigation by Fulton in 1807, the discovery of electro-magnetism by Oersted in 1819, or the opening of the Liverpool and Manchester Railway in 1830; but the immense activities of the time are reflected in the pages of many publications. "A picture of the world in 1834 presents many interesting details and includes many notable men. In Great Britain, among the outstanding men of science were Brewster, Lyell, Herschel, Dalton, Whewell, Babbage, Faraday, Wheatstone, Forbes, Murchison, and Graham; abroad, among the most distinguished were Ampère, Arago, Liebig, Oersted, Hansen, Gauss and Humboldt. In 1834, Sir John Herschel, at the Cape, was engaged on his survey of the southern heavens; Faraday at the Royal Institution was investigating the action of the voltaic cell; Wheatstone at King's College was determining the velocity of electricity; Liebig at Giessen was making his laboratory the Mecca for young chemists; while Darwin in the Beagle was exploring the coasts of South America."

WESTWARD HO!

DURING the latter part of June, July, and August, I, accompanied by my wife, paid a visit to the western part of our dominion; and as we visited nearly all the cities of the west, I took it upon myself as an officer of The Royal Astronomical Society of Canada of long standing, to pay my respects to the executives of our various centres where I might find them and exchange salutations on behalf of the executive and members at Toronto, and for that matter, for the whole society.

At Victoria we exchanged greetings with Dr. Plaskett, the genial director of the Dominion Astrophysical Observatory whom most of us have known and whose successful career we have admired for many years; also with Mr. Harper who with Dr. Plaskett has in the past honoured the society as General President, and to Dr. Pearce, through whose good offices we were enabled to see through the observatory and view its equipment. It was at this point that Mrs. Collins was delighted to be allowed to twirl the great massive telescope around as readily as if at the steering wheel of an automobile.

Dr. Pearce was good enough to drive us around to see some of the sights of the beautiful city, and with him in the evening we were entertained by Mr. Brydon, the president of the Victoria Centre, and his good wife at their charming residence near the sea. Here we discussed affairs relating to the welfare of the society and astronomical matters in general. Mr. Brydon showed us his telescope which with some accessories he had purchased from our own Mr. A. F. Miller. It is housed in a very presentable dome.

Our scheduled time would not permit us to visit our old friend Mr. F. Napier Denison, the director of the Meteorological Observatory at Victoria, whose white-domed buildings stood out prominently in the distance. I regretted omitting seeing the interior of this as I understand there is a fine up-to-date equipment there. I could not refrain, however, from calling Mr. Denison by 'phone and saying hello! and exchanging good wishes, and so bidding good-by to beautiful Victoria.

In Vancouver we found that Dr. Ure, the Vancouver Centre president was away from home, but fortunately we had the pleasure

of spending part of an evening with the president of last year, Mr. Teasdale, on his lawn where an open meeting of the Centre was being held, and had a glimpse of Jupiter through a 6-inch reflecting telescope Mr. Teasdale himself had made. We spent a very pleasant though late hour with Mr. and Mrs. Teasdale and a few of the members.

At Lethbridge we were the guests of Mrs. Margaret Paterson, who was with our Eclipse expedition of 1932 at Louiseville, Quebec, and who had placed her car at the service of the expedition and drove it herself at that time.

We failed to get in touch with any of the members at Regina but had a pleasant chat with Mr. W. P. Taylor and Mr. A. B. Mackay at Calgary who are members of our society. There was some years ago an active local society here but it became dispersed during these depressed times. There is a possibility that something of the sort may be organized again in busy and compact Calgary.

In Edmonton we found an active Centre of the society. Here through the good offices of mine host Mr. Porter of The Strathcona, we were shownu around the University Buildings and were enabled to see Mr. Hilton, the president of the Edmonton Centre, Mrs. Hilton, Dr. Gowan, and Mr. Higginbotham, who were kind enough to call at the hotel in the evening where we discussed questions of interest to us all.

Viking, Alberta, was our next call, where we had the pleasure of greeting our old friend and one-time member, Mr. H. B. Collier, who still possesses a fine 3-inch telescope with prism eyepiece. Though like the most of us he has been hit by the depression, Mr. Collier has not lost his interest in the queen of the sciences. He remembers with some pleasure the model of the moon's surface he made in Toronto some years ago and recalls many of the pleasant meetings attended in the long ago.

At Saskatoon we were not a little surprised to see the beautiful College and University Buildings they have there and the splendid little domed observatory with its 6-inch Cooke refractor and equipment. In the absence of Professor Pyke this department was in charge of Mr. James Duff, late of Victoria. There is no Centre of the society in Saskatoon at present but it may not long be so when

prosperity succeeds in getting around the corner. There is no city in the west that one may be more delightedly surprised In than the substantially built and beautiful Saskatoon.

Our last call was at Winnipeg where we saw and exchanged salutations with Professor Warren, Mrs. E. L. Taylor—whom we entertained as Winnipeg's representative in Toronto two or three years ago—and Winnipeg's president, Mr. D. R. P. Coats, who also has constructed a telescope and is an enthusiastic observer of the skies.

I found an enthusiastic welcome from our members everywhere I went and evidence of the comradeship emphasized by this personal contact through mutual exchange of greetings. One of the queries continually asked me was regarding the progress of the David Dunlap Observatory. The interest in it is dominion-wide. No doubt the same cordial greeting awaits any of our members visiting at any of our other Centres throughout the dominion, and I am sure Toronto will not be the least in its cordiality extended to visiting members from other Centres.

J. R. Collins

REVIEW OF PUBLICATIONS

Relativity, Thermodynamics and Cosmology, by Richard C. Tolman, Professor of Physical Chemistry and Mathematical Physics at the California Institute of Technology. 502 pages, 6¼ × 9¼ in. Oxford University Press (Canadian Branch, Toronto). 1934. Price, $9.00.

It has been remarked that a book should be reviewed only by one who himself is able to write it. If that principle is insisted on, these paragraphs must be considered only a "notice". Perhaps that is the best description of them anyway. But any person who has even a moderate acquaintance with the subjects treated in this book will recognize at once that it is comprehensive, lucid and authoritative. Although there has been much discussion on Relativity in recent years, scarcely a book in English has been written on it. The time is opportune for a systematic treatment of the whole subject and Professor Tolman gives it here in a masterly fashion. The book is one of the volumes in the International Series of Monographs on Physics edited by R. H. Fowler and P. Kapitza.

The author's method is admirable. In his introduction to the book (11 pages) he outlines explicitly what he proposes to do, and when beginning each division of the subject a further concise statement of the treatment to be followed is presented. In this way the reader sees clearly the path he is to follow. Further, the language is simple and straightforward.

It is quite impossible in the space available here to give an understandable outline of the contents of the book. The main divisions of the work are as follows: I. Introduction; II. The special theory of relativity; III. Special relativity and mechanics; IV. Special relativity and electrodynamics; V. Special relativity and thermodynamics; VI. The general theory of relativity; VII. Relativistic mechanics; VIII. Relativistic electrodynamics; IX. Relativistic thermodynamics; X. Applications to cosmology. The last division extends to 150 pages and of this about 40 pages are devoted to a

discussion of the significance of the "red shift". It will be interesting to quote the last paragraphs of this section:

> It may seem somewhat ironic to conclude our elaborate treatment of the properties and temporal behaviour of specific cosmological models, with words which disparage their applicability to the actual universe. Their study, however, has certainly informed us as to conceptual possibilities, and has provided a provisional and approximate theoretical background which has already been successful in correlating a considerable number of the phenomena of the real universe.
>
> As a final remark it is desirable to emphasize the special necessity in the field of cosmology of avoiding the evils of autistic or wish-fulfilling thinking. In the first place, the problems of cosmology are necessarily extensive and intricate and must be attacked in the light of very meagre information. Hence, we must be careful not to substitute the comfortable certainties of some simple mathematical model in place of the great complexities of the actual universe. In the second place, it is evident that the past history of the universe and the future fate of man are involved in the issue of our studies. Hence we must be specially careful to keep our judgments uninfected by the demands of theology and unswerved by human hopes and fears. The discovery of models, which start expansion from a singular state of zero volume, must not be confused with a proof that the actual universe was created at a finite time in the past. And the discovery of models, which could expand and contract irreversibly without ever coming to a finite state of maximum entropy and rest, must not be confused with a proof that the actual universe will always provide a stage for the future rôle of man.
>
> It is appropriate to approach the problems of cosmology with feelings of respect for their importance, of awe for their vastness, and of exultation for the temerity of the human mind in attempting to solve them. They must be treated, however, by the detailed, critical, and dispassionate methods of the scientist.

In the appendices there are symbols for quantities, formulae of vector and tensor analysis and useful constants. There is a great variety of type required, and it only remains to be said that the book is produced in a very creditable manner.

C.A.C.

Il Cielo e le sue Meraviglie (*The Sky and its Wonders*), by Pio Emanuelli. xl, 314 pages (including 150 plates), 8½ × 12 inches. Milan: Hoepli, 1934. Price, 130 lire (about $11.20).

This is surely the finest atlas of the heavens which has been published, and there is in it much besides the pictures which is of

decided value. At the beginning there is a brief outline of our knowledge of the solar system, our galaxy, and the universe beyond it, revised to a late date.

To the moon there are devoted 14 plates; the sun and the aurora, 38; the planets, 9; comets and meteors, 13; star-fields, 17; star clusters, 5; diffuse nebulae, 25; extra-galactic systems, 15; observatories and telescopes, 14. On the page opposite each plate is an excellent summary of the facts relating to the object (or objects) illustrated, together with an extended bibliography giving the important references to the subject. Professor Emanuelli has endeavoured to make this information full, accurate and recent. The photographs chosen for the atlas are good representatives of each class and the reproductions are very good. Author and publisher are to be congratulated on the splendid volume.

C.A.C.

NEWS AND COMMENTS

Notes from the Dominion Astrophysical Observatory, Victoria, B.C.

In continuation of the observing statistics from the December, 1933, issue of the Journal we have the following from the records of the Observatory.

	1933-34		15-Year Average	
Month	Nights	Hours	Nights	Hours
November	7	56	12	86
December	6	18	14	69
January	7	38	10	66
February	16	127	13	90
March	20	114	15	98
April	17	123	17	98
May	19	99	21	105
June	26	132	19	88

The first three months on the list are practically records for poor observing weather since the Observatory was opened. Fortunately the tide seems to have turned and the improved conditions are welcome. June was a record for the amount of clear sky both day and night.

The number of visitors to the Observatory is on the increase. For the eight months listed above—and these are not tourist months—the number was 5,257, as compared with 3,266 for the corresponding eight months of the year previous.

Dr. C. M. Huffer, of the Washburn Observatory, who has been spending some time at Mount Wilson, spent a day at our Observatory after attending the Berkeley meeting of the A.A.A.S.

Miss Davis, a graduate of Vassar College and for the past year at Mills College, California, spent a few hours here on her way to her home in the Middle West. She is interested in variable stars and expects to continue the study of these interesting objects.

Mr. Abrams, a graduate student of Harvard, paid us a visit between boats when returning to his home in San Francisco. He has been working this summer at the Lick Observatory.

Mr. Chappell, photographer at the Lick Observatory, accompanied by Mrs. Chappell, spent a few hours at the Observatory here recently.

Miss Anne S. Young, Director of Mount Holyoke Observatory, spent a couple of days in Victoria when on her way to Alaska in the first week in July.

Dr. R. O. Redman, formerly on the staff here for a couple of years and now Assistant Director of the Cambridge Solar Physics Observatory, England, returned as a volunteer assistant for six weeks in July and August.

Mr. S. N. Hill, a member of the staff here for the past eleven or twelve years, has been forced through illness to retire. He has been granted superannuation from the end of September. The staff presented him with a fountain pen and pencil set on the occasion of his retirement.

The Director, Dr. J. S. Plaskett, went east to attend the convocation exercises in connection with Queen's University, Kingston, on May 9. He was one of those receiving the honorary degree of LL.D. and we extend our congratulations. Later he visited in Toronto, Cleveland and Ottawa and also attended the meetings of the Royal Society in Quebec.

The Assistant Director, W. E. Harper, your scribe, also attended the Quebec meeting, and paid a brief visit to Toronto and Ottawa as well. On his way east he stopped over a day in Edmonton to give an address to the Local Centre of the R.A.S.C. He has pleasant recollections of the kindness shown him by the people of Edmonton.

The Newtonian mirror of the 72-inch telescope has been sent to Pasadena to be coated by the new aluminium process. Dr. Adams has the thanks of the Director and staff here for doing this and without expense to us. If the results with the new coating should be as good as expected it is likely that arrangements will be made to have the Cassegrain secondary aluminized also.

The sum of $36,000 included in the estimates of the Federal Public Works Department for improvements to the Observatory grounds has, according to the local press, been passed by Parliament. We have not the details of just what is contemplated being done.

W. E. H.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

The Perseid Meteors

At the date of writing it is too early to say very much about the Perseid shower but the indications are that, owing to fairly good weather conditions, a large number of observations were made in Canada. The report of these observations will have to be left to future issues of the Journal. The plates exposed at the David Dunlap Observatory have not yet been carefully examined but it is known that at least two Perseid spectra were photographed with special red sensitive Eastman plates. These meteor spectra are the first photographed in Canada and the first to be obtained anywhere with red sensitive plates.

Notes on Recent Meteoric Research

In the study of meteors, a branch of astronomy peculiarly adapted to amateur observation, it is of great interest to learn what is being done in this field in various parts of the world. To this end several random items of interest concerning recent meteoric research in foreign countries are summarized below.

United States

The excellent work of the American Meteor Society, under Dr. C. P. Olivier, is well-known to all astronomers. Of particular interest is the comparatively recent development in this society of local groups of members under a regional director. This makes for increased efficiency in many ways. The regional director can personally plan co-operative observing programmes for his section of the country and in this way ensure that these observations are of the maximum scientific value. He can also render great service by contacting the local press immediately upon the appearance of a bright fireball, and requesting the observations of eye-witnesses. It is obvious that such work is best when centred at a local headquarters where the reports can be collected and often much of the reduction performed.

It should be mentioned in this connection that Canada is almost untouched territory as far as systematic meteor observations are concerned and that a real aid to astronomical research may be rendered by amateurs in various parts of Canada who would be willing to act as local representatives of the Royal Astronomical Society of Canada in the collecting of meteor observations and in the planning of observational programmes. The writer would be very glad to hear from anyone who has interests which lie in this direction.

New Zealand

All observations of meteors made in the southern hemisphere are of great value as so little work has been done on the southern meteor radiants. The most systematic work in this field is being performed by a few enthusisatic members of the Meteor Section of the New Zealand Astronomical Society, headed by Mr. R. A. McIntosh, F.R.A.S. The last complete report,* covering observations up to the end of 1931, brings the total number of radiants listed by this group up to 603. These observers are accumulating a steadily increasing quantity of excellent scientific data on southern meteors.

Czechoslovakia

We welcome the appearance of another publication intended to interest amateurs in making serious contributions to astronomy. *Astronom Amatér,* published in Prague, appeared during the first part of 1934 and is announced as the Bulletin of the Young Generation Club of the Czech Astronomical Society. It is concerned with the reporting of various types of amateur endeavour, particular attention being paid to variable stars and meteors. The latter department is in charge of Dr. V. Guth and promises to be a valuable factor in promoting co-operation among meteor enthusiasts in Czechoslovakia.

Italy

Mr. G. B. Lacchini, one of the ace observers for the American Association of Variable Star Observers, makes an interesting report of telescopic meteors† which he has observed while estimating the

*Transactions of the New Zealand Institute, vol. 63. page 433, 1934.

†Pub. del R. Osservatorio Astronomico di Trieste, vol. 2, page 157, 1934.

magnitudes of variable stars. During the years 1928 to 1933 a total of 22911 observations of variable stars were made with a 6-inch telescope, the eyepiece usually used having a field of 45 minutes of arc in diameter. Mr. Lacchini estimates that each observation occupied one minute on the average. In more difficult cases where a longer time was required the field was usually smaller, which compensated for the extra observing time. In the 382 hours when the star field was being examined, 126 telescopic meteors were observed. Magnitudes were estimated in 116 cases and the magnitude distribution, being of considerable interest, is shown in Figure 1. This

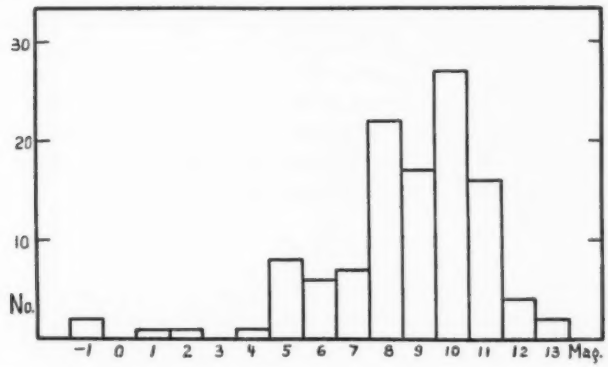


Fig. 1. The Magnitude Distribution of 116 Telescopic Meteors.

confirms the fact noted by Olivier that the numbers of telescopic meteors are approximately constant from the 8th to the 11th magnitude.

Russia

Regular meteor observations are published in the circulars of the Tashkent Astronomical Observatory, where Dr. V. Malzev has done a great deal in furthering the cause of meteoric research. Many valuable articles in this field are also published by Dr. I. Astapowitsch in the Astronomical Bulletin of the Russian Amateur Society for the Study of the Universe. It is to be hoped that in the future these publications will have a more general circulation among the astronomers on this continent.

France

In the June issue of *L'Astronomie* Dr. D. Belorizky of the Marseilles Observatory reports on the testing of two lenses to be used for meteor photography. One was a Zeiss Biotar of focal length 7 cm. and focal ratio 1.4; the other a Zeiss Tessar of focal length 16.5 cm. and focal ratio 2.7. On two star trail plates taken simultaneously it was found that the first lens showed stars down to magnitude 7.9 while the second showed stars of magnitude 9.1. Dr. Belorizky states that the Zeiss Tessar lens would probably photograph meteors of zero magnitude and brighter and that he intends to use it on the Perseids and Leonids. It may be noted here that it has been the common experience of the writer that the lenses of very small focal ratio are often not as satisfactory for meteor photography as those nominally slower. In the so-called fast lenses efficiency is lost through increased glass absorption and reflection and poorer definition and for objects like star trails or meteors this outweighs the gain due to the large relative aperture.

Japan

It is only recently that amateur astronomy has made very much headway in Japan. The writer has noted with great interest that Mr. Y. Iba established a small observatory near Kobe a few years ago. Part of the programme of this observatory has been the search by Mr. S. Imoto of the old Japanese and Chinese records for accounts of ancient meteor showers and meteorite falls. This long neglected field is now receiving some well-deserved attention and Mr. Imoto and other Japanese astronomers have recently uncovered many valuable records. We are glad to observe this new interest in meteors in Japan and it is to be hoped that in addition to the continuation of the historical research, modern meteoric observations will become more common in the Japanese Empire.

P. M. M.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Simultaneous Discoveries

On June 16, 1934, there was a celebration at Lacock Abbey, Wiltshire, of the centenary of the invention of photography. Working in that house Henry Fox Talbot in 1834 first succeeded in producing photographic impressions on paper. There were many relics on exhibition, including a letter from Sir John Herschel in 1839 suggesting the term "photographic" in place of the word "photogenic" which was preferred by Fox Talbot.

It was stated by Herbert Lambert, of Bath, that although Fox Talbot's first experiments were made in 1834, it was not until 1839 that, stimulated by the work of Daguerre, he announced his invention to the Royal Institution, a few days before Daguerre made his communication to the French Academy. The two men were working along independent lines and made what were really two different inventions with the same end in view. Fox Talbot's calotype and the Daguerre process both used as their basis the sensitiveness of silver salts to light, but the methods and chemical reactions were quite different. Daguerre used silvered plates which he sensitized with iodine and subsequently developed by mercury vapour, while Fox Talbot produced a sensitive paper which he developed with gallic acid and fixed with hyposulphite of soda.

The above investigations by Fox Talbot and Daguerre recall other simultaneous discoveries. One is the famous theoretical prediction of Neptune by Adams and Leverreier in 1846. Another is the practically simultaneous determination of stellar parallaxes by Henderson, Bessel, and Struve in three different countries in 1838. Another remarkable coincidence occurred in 1868 when Lockyer and Janssen presented papers at the same meeting of the French Academy describing a method of observing solar prominences without an eclipse. It is also on record that on the very same day in 1876 Alexander Graham Bell and, a few hours later, Elisha Gray made application for patents on a practical telephone. In each case

it would seem that the time was ripe for the discovery and several persons were pondering on the various matters mentioned.

Tribute to Director R. Meldrum Stewart

In the *Ottawa Citizen* for July 25, 1934, appears a fine tribute to Director Stewart of the Dominion Observatory, Ottawa, written by J. H. Ogden. As it almost fills a column of the newspaper, it is too long to give here in full and a few quotations must suffice.

It is a trite saying that "A prophet is not without honour save in his own country and in his own house." The saying is very true, for we often regard the accomplishments and estimate the qualities of the men of other lands and of other ages as superior to the best of those who live and work amongst us in our own day, in our own land, and even in our own city. These are too near to us—our perspective and focus need correcting and adjusting.

* * *

Appointees to executive office may be divided into two classes: (1) those upon whom the appointment confers an honour—merely this and little else; (2) those who adorn the office, and confer honour and distinction upon it by virtue of their ample and superior endowments and sheer force of character and personality. Their "qualifications" outmeasure any scheduled list of "requirements" that are tabulated as the conditions of appointment—they bring to the office subtle qualifications that cannot be tabulated.

There is no manner of doubt whatever as to which of these classes our chief astronomer belongs — it is immediately apparent to anyone who is qualified to form an opinion; although, to discover and realize it will require somewhat of intimacy, seeing that an innate modesty, always an attribute of true greatness, is his prominent characteristic. Publicity and self-advertisement are outside his repertoire.

* * *

It has been a much prized privilege during the last five years to come into frequent contact with him, and to receive the invaluable and willing help that he is at all times so ready to give, and which is given in such a kindly manner as to obviate any feeling of embarrassment. This gentlemanly kindliness is a characteristic which must have impressed everyone who has approached him for any purpose whatever—it is always present, and makes consultation very pleasurable.

* * *

It is a psychological truism that the personality of an executive is reflected in his subordinates and stamps itself on the work over which he presides. Although a mirror never delivers the same amount of light that it receives, it is a pretty faithful criterion of that which is reflected.

Any observant and discerning visitor to the observatory during working hours will not fail to "feel" the atmosphere of the place, and he will surely

find that, over and above any influence of the personalities of the individual members of the staff (a conscientious and worthy body of men), there is a penetrating influence, a kind of exhalation, that pervades the institution and gives it its tone and distinction. Like the streams to the hills, it is directly traceable to the fountain head.

It is not surprising to find that he is held in deep respect and warm affection by the members of his staff; and his relationship to them is that of a faithful friend.

The present writer became acquainted with Mr. Stewart when the latter was a student at the University of Toronto, from which he graduated with distinction in 1902; and unbroken friendship since then gives a basis for supporting heartily Mr. Ogden's appreciative remarks.

The Aurora at Low Levels

Referring to the article by Dr. C. S. Beals in this Journal for May-June, 1933, (vol. 27, p. 184), Mr. J. Ed. Fraser of North Lonsdale, North Vancouver Dist., under date June 7, 1934, relates observations made in August, 1916:—

On the date above mentioned, the evening being clear, I took a stroll into the suburbs of Winnipeg. Before facing about to return I stopped to view the northern sky which displayed the aurora as brilliantly as I had ever seen it.

This spectacle was in the form of a great tent, the apex appearing exceedingly high but the basic curtains seemingly very low.

I have no doubt but that the rays or streamers, as they are variously called, were strictly parallel and the illusion of convergence merely a matter of perspective. But to see a bundle of light streamers many miles thick reduced to almost zero by perspective would signify a great altitude.

The lower curtains were coarse, brilliant and very active and, as I watched, I had to admit to myself that they did not appear to be very far up.

Resting from looking upward I stood looking about me. There were two vacant building lots between me and an eight story building facing another street. The side towards me was blank and dark and, as I looked towards it, I detected a movement of light. Concentrating my attention upon it I was surprised to see tenuous, slanting streamers of light playing upward and downward. They would descend, with a movement that was not particularly swift, touch the earth and retract, much more quickly, some 50 or 60 feet, and then repeat the performance. The lower ends were irregular, not unlike inverted flames, and they played about the surface of the ground much more like a bundle of separate streamers than one of great volume. When I followed the inclination of the rays upward I found that they registered

perfectly with the grand design overhead. In that instant I knew that previous theories as to the cause of the diffused character of the illumination were in error. Yet the fact remains that these lights most frequently do choose a good altitude and it may happen that barometric pressure has some influence.

I carefully scanned the morning papers to see if they would mention the fact that Winnipeg city had been bathed in the aurora the previous evening but beyond noting the failure of the telegraph lines to function for a time there were no comments.

The illumination was equal to good moonlight but, of course, without the shadows. Its brilliance, however, seems to be essentially a matter of depth and quantity. The cumulative effect of many millions of cubic feet of an exceedingly ghostly glow may result in good illumination.

C. A. C.

THE SOLAR SYSTEM

(*Verses for the young*)

The earth spins on its axis
  And gives us day and night
By facing, or by turning from
  The sun, the source of light.

It speeds upon its journey
  Around the parent sun,
And keeps on going year by year,
  Its circlings never done.

In these great revolutions
  Its orbit is inclined,
And thus we have the seasons,
  As everyone will find.

The moon's a sort of valet
  To make the earth more bright;
It borrows rays of sunshine
  And gives them out by night.

Some of the other planets
  Have several satellites,
And finding out about them
  Is one of our delights.

Each planet has its orbit,
  And each one keeps its course,
Being held in its position
  By the sun's unseen force.

The comets are erratic
  And seem to go astray;
But they, too, have their periods,
  The sun holds them in sway.

So, in majestic order,
  The system of the sun
Moves on and will continue
  While unborn ages run.

The sun controls these bodies,
  Life, light and heat are sent;
But back of his controlling
  Is God Omnipotent.

Toronto, Ont. H. W. BARKER.

MEETINGS OF THE SOCIETY

AT WINNIPEG

January 10, 1934.—The first meeting of the year 1934 was held in Theatre F, University Building, Broadway, at 8.15 p.m.

The retiring president, Mr. A. W. Megget, made some fitting remarks of introduction and welcome to Mr. D. R. Coats on his assuming of the presidency.

Mr. Coats replied in his usual genial manner. He spoke of having been a member in Montreal, and said that it was through Mr. Megget that he joined Winnipeg Centre. He gave a summary of the considerations and decisions of the meeting of the Executive held December 21 at his home. Mimeographed copies of the regulations governing the loaning of the telescope are to be available for members of the society.

Mr. Megget then gave the first of his monthly 10-minute talks on celestial events of the month. He gave an illustrated description of the great telescope at Victoria, second largest in use, and also discussed Venus and Jupiter, and the principal bright stars visible at present in our skies.

Mr. L. T. S. Norris-Elye gave the address of the evening on "The Telescope". Using the telescope, he demonstrated the steps taken in its erection; and the precautions necessary in its use and handling were carefully explained. Much harm may result from exposure of the oculars to the sun's rays. He showed the method of taking it apart, and wrapping the different parts. Refracting and reflecting telescopes were compared, under the various headings, magnification, power, advantages of each, and the cost.

The method of searching for objects with the finder was shown, and then the adjustments made. It was an interesting and enlightening address.

February 14, 1934.—The meeting was held at the same place and hour. In the absence of the president, Mr. A. W. Megget took the chair. The following names of prospective members were proposed:—Messrs. R. D. Colquette, C. D. Dorsett, V. D. Newman, Duana McKenzee and Miss Jean Ackerman.

Mr. Megget gave his 10-minute talk on celestial events of the month. He spoke of Leo, a spring constellation, and also of Orion with its giant stars and nebula. Mira Ceti was noted as a long-period variable, 331 d., 8 h., and varying from the 2nd to the 9th magnitude. Venus and Mercury were also considered.

The address of the evening was given by Mr. A. V. Pigott, who spoke on "New Ideas of the Universe". The lecturer spoke of the beliefs and ideas held until comparatively recent times, one of which was that space was infinite. The Newtonian theory of three-dimensional space—length, breadth

and depth—was noted, to which many still adhere. Then Einstein projected the new idea of the time-dimension in his Relativity Theory.

The speaker dwelt on the motion and velocity of bodies moving through the ether, under *Length, Mass, Time* and *Space*. Since rays of light from stars are deflected when passing near the sun, it is considered that light has mass. It is said that the sun gives us 160 tons of light a day, and this might be illustrated as a pound of matter scattered over a million cubic inch side.

JEAN C. HOWEY, *Recorder*.

AT VANCOUVER

April 10, 1934.—The twenty-fourth regular meeting of the Centre was held in the University of British Columbia, at 8.15 p.m., Dr. W. Ure presiding.

Dr. Ure referred to the passing of Mr. N. H. Hawkins, one of the Centre's most active and valued members. It was decided to send a letter of sympathy to Mrs. Hawkins.

The following were elected members of the society:

(Mrs.) Laura Anderson, 924 W. 17th Ave., Vancouver
(Mrs.) W. J. Rogers, 4548 W. 12th Ave., Vancouver
Charles Ney, 3126 W. 38th Ave., Vancouver
G. A. Morgan, 1575 W. 11th Ave., Vancouver
Donald Ing, 3350 Manitoba St., Vancouver
D. L. Shaw, 2900 St. Kilda Ave., North Vancouver

The programme for the evening was in the hands of four members of the society. Professor A. B. Lighthall gave a survey of the stars and planets to be seen during the months from May to September inclusive. He pointed out methods of locating the constellations and individual stars, the best times for observing them, and some of their chief characteristics. Lantern slides illustrating his discussion enabled the audience to get a clear picture of the heavens.

Mr. H. A. Newton spoke on "The Use of the Observer's Handbook". Members of the society brought their Handbooks to the meeting, and Mr. Newton explained and cleared up difficulties, particularly in the question of "Time". By means of charts and diagrams he showed the reasons why we have adopted our present methods of reckoning time and the reasons why the sun and our clocks do not agree.

A review of a recent book, "Present Day Astronomy", by J. W. N. Sullivan, was presented by Mr. C. A. McDonald. Mr. McDonald recommended this book as a clear exposition of accepted facts, vividly and truthfully described. To give the audience an idea of the scope of the book, he referred briefly to the subjects treated and the chief subdivisions.

WALTER H. GAGE, *Secretary*.

AT VICTORIA

The spring session of the Victoria Centre was concluded with a delightful address delivered by Dr. C. S. Beals, F.R.S.C., on "Science and the Future".

In his opening remarks Dr. Beals stated that modern science, as an institution, may perhaps be said to date from the seventeenth century, that remarkable period with which we associate such famous names as Galileo, Newton, Huyghens, Leibniz and Descartes. By the term Modern Science was meant the application of the powers of the human intellect to the careful, systematic, persistent study of the world of nature; using every device provided by mathematics and logic to correlate events, and depending upon observation and experiment as the only final test of the validity of results.

The idea of the natural universe as a problem to be solved is very ancient and certainly far ante-dates the Greeks, but the notion of the experimental method as the only final test of any deduction or conclusion is relatively new and had its first conspicuous triumphs in the period to which we have just referred. Since that time the elaboration and refinement of scientific methods, the enlistment of greatly increased numbers of workers and the improved facilities for the publication and general dissemination of knowledge concerning new scientific discoveries have gradually led to a community of effort in the field of science which tends more and more to take on the complexion of an international world-wide organization. The co-ordination of effort which has been achieved among scientists does not, in the main, depend upon the existence of any central authority directing affairs though there are certain scientific associations, of which the International Astronomical Union is a good example, which do exercise some authority of this kind. It depends rather upon the completeness and efficiency of the machinery for disseminating information. Every scientific discovery or advance is immediately published and usually every effort is made by the discoverer to bring his results to the notice of others working in the same field. Publication of results frequently takes the form of articles contributed to scientific journals although many research institutions issue their own publications directly. The Victoria Observatory is regularly in receipt of twenty-five astronomical journals and fifty publications of observations. These come from every county in the world and the languages in which they are printed include Russian and Japanese, which few people of this continent can read. The great majority of these publications are available in English, French and German. "To my mind," said the lecturer, "these publications form a rather interesting exhibit as they represent the life blood of the astronomical world." Copies of each of these publications go to evey scientific library in the world and make it possible for every research worker, in however remote a location, to keep abreast of the latest developments in his field.

Although only astronomical publications were referred to by Dr. Beals as an illustration of the manner in which scientific knowledge was now disseminated he drew attention to the fact that these were, relatively, only a very

small part of the volume of scientific literature of the day. In this connection it was stated that it is estimated that there are in circulation at the present time in all branches of science several hundred periodical and research institute publications and some ten to twenty thousand articles appear yearly which contain the results of original research and scientific investigation. In addition to these, it was pointed out, that the "community of interests" among different research workers usually leads to a rather extensive personal correspondence on scientific matters. Travel and study in foreign countries and visits between members of different scientific institutions also represent a relatively important cog in the machinery which co-ordinates scientfic activities. More important still are the national and international gatherings of scientists such as the Pacific Science Congress which met in Victoria and Vancouver in 1933, the International Astronomical Union meetings which were held in Cambridge, Mass., in 1932, and which will be next held in Paris in 1935. These various agencies provide for a constant exchange of information and inter-play of ideas in the world of science which not only enables each worker to keep abreast of developments of his subject but serves to prevent too much unprofitable overlapping, yet at the same time provides the necessary mental stimulation and inspiration so necessary in all research activities.

Referring to another phase of scientific activities Dr. Beals drew attention to the fact that of late years the research staffs maintained by certain large commercial corporations have made valuable contributions to scientific knowledge and whilst the results of some of their investigations are not immediately made public (because of the commercial value of exclusive patent rights) many of their discoveries are published in the usual way in well-known scientific journals. In addition to the types of institutions above mentioned there is a small but not negligible number of persons who, with the necessary means and leisure, maintain private laboratories in which they pursue research activities.

The number of scientists listed in a biographical directory for North America issued in 1932 was given as 22,000. This list, however, it was pointed out, was unlikely to be complete as many of the younger research workers would not be included therein. Figures, stated the lecturer, are not available for other countries but it seemed safe to say that the scientific fraternity throughout the world numbers from fifty to one hundred thousand persons. From a numerical point of view these may not appear particularly impressive but the influence of science on human affairs makes them more significant than they seem. "I venture to suggest," said Dr. Beals, "that modern science as represented, on the one hand, by its personnel and its store of accumulated knowledge and technique, and, on the other, by the corrective and directional influence which it exerts on intellectual activity of all kinds, is the most stable and potentially powerful institution in the world to-day. Its strength lies in its complete reliance on nature herself. It is compara-

tively little affected by political changes though research work may suffer a temporary set-back during an unenlightened regime. The clash of religious beliefs has comparatively little effect upon it, though a dogmatic theological belief, held in powerful quarters, may hinder for a brief period research of a particular kind. It is unaffected by the relative ascendancy of any particular race since all the civilized peoples of mankind, regardless of race or colour, have shown themselves capable of effective scientific investigation."

Looking forward, then, for the next few hundred years we may, with some confidence, predict that whatever happens in Europe, whatever happens in Russia; however the British Empire may prosper or decay; however the balance of world power may be held between the nations of the west and the teeming millions of the east, the world of science will continually enlarge and broaden its domain and will go forward with now slackened, now accelerated, pace to a more and more complete mastery over the forces of nature.

The history of science, said the lecturer, is like a continued story in a magazine: it stops short at the most interesting point, the present. Detailed speculation as to the future course of pure science is almost as futile as would be the attempt to predict the exact positions of the footsteps and hand-holds of a mountaineer who is climbing a cliff. Certain general trends may, perhaps, be vaguely indicated although new discoveries which are being made every day may so divert scientific effort that all prophets will be confounded.

In physics the attack on the problem of atomic structure is being pressed with vigour. We have already had to discard one old idea of the atom as a miniature solar system with the nucleus as sun and electrons or planets in their orbits revolving around it. The new atom is quite different. Clothed as it is in mathematical terminology, with much of its physical reality gone, it seems somewhat unsatisfactory to the non-specialist. It has been exceedingly successful, however, in accounting for observations which were before inexplicable and seems to hold out great possibilities for the future. The recent discovery of the neutron, the positron and the new hydrogen isotopes show that in atomic physics experiment is keeping pace with the remarkable theoretical developments of the past few years and there is every reason to expect substantial progress in this field in the near future.

Another outstanding problem which physics shares with astronomy is the question of the mutual transformation of matter and radiation. This problem, which is intimately connected with atomic physics, is also of importance in connection with the source of internal energy of the stars. It is believed that matter can be changed into energy and vice versa but the process by which this takes place has so far escaped us. The matter is being made the subject of intensive theoretical investigation, however, and it may be that the solution to the problem will soon be found.

Still another unsolved problem is that of the expanding universe as revealed to us by the large recessional velocities of the spiral nebulae. Some believe

that this problem is well along the way to solution but this view is by no means universal. The complex philosophical question involved here makes the recession of the nebulae perhaps the most interesting phenomenon in the whole realm of physical science. It is safe to say that attempts to explain it will continue to enlist the imagination of mathematicians and physicists and he would be a bold man who would predict anything like complete success in the near future.

It would be most interesting, said Dr. Beals, given a sufficiently broad knowledge, to review other branches of science and call attention to the outstanding problems of the day whose solutions may be looked for in the near future. For many years, he pointed out, physics and astronomy have held first place among the sciences, owing, no doubt, to the fact that they lend themselves to accurate observation and are susceptible to elegant forms of mathematical analysis but he pointed out that the more complex science of biology is claiming more and more attention in recent years and that there was reason to expect a shifting of emphasis in the world of science, more attention being directed to the study of biology at the expense of the physical sciences. There seemed little doubt but that the remarkable and mysterious qualities of living matter, and the importance of biology to man, himself one of the principal objects of study, will result in attaching an ever-increasing number of research workers in this fascinating field of investigation. The lecturer suggested that it might be worth while to have a biologist address the Centre, the breadth of the constitution of the society being sufficient to justify such a departure from the usual procedure.

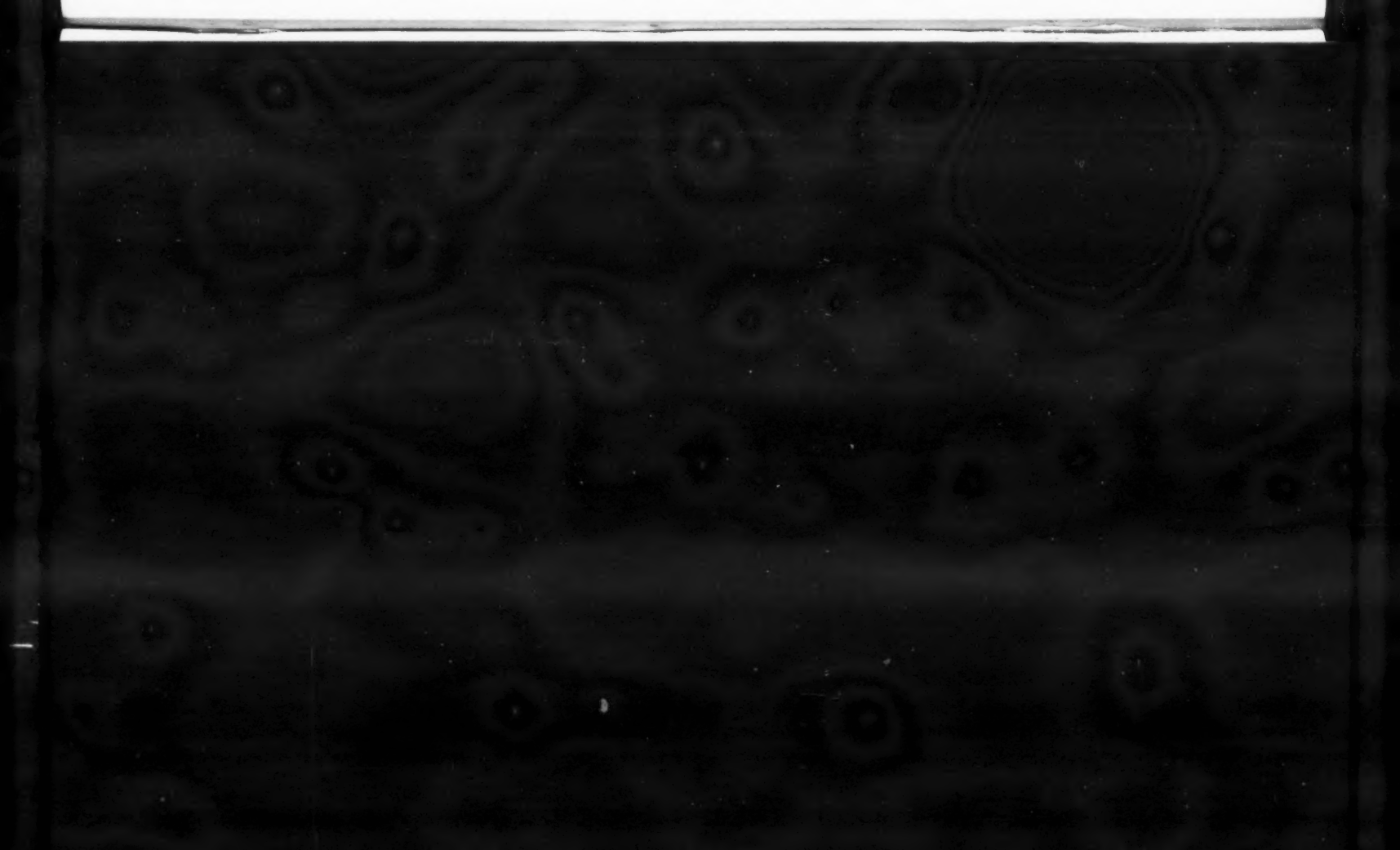
Whilst the research workers in pure science naturally take the lead in exploring the unknown, that is not to say that their function is more important than that of the technician. Whilst it is difficult to predict the future course of pure science, for applied science the situation is somewhat different. There is necessarily a considerable time lag between the announcement of a new discovery and its application in practical affairs. By way of example the lecturer instanced the fact that the first observations of photo-electric effects were first made in 1887 but pointed out that the photo-electric cell, as a useful instrument in the laboratory and workshop, has really only come into its own during the past ten years. As a result of this time lag there are many scientific discoveries waiting to be used as well as many others the full possibilities of which have never been fully realized. In thinking of the influence of science upon the life of the future it is thus natural to think mainly of the fuller usefulness of scientific knowledge already available, although the prospect of new discoveries is always in the back of our minds and we feel that, in trying to foresee the future, we are far more likely to err on the side of excessive caution than to go to the opposite extreme.

We are all familiar with the remarkable success in the application of science to industry in the last hundred years. We know that it has greatly increased the productive power of the world, and, as a consequence, raised the

standard of living in civilized countries. This raising of the standard of living has, apparently, been arrested for the present but few believe that the slowing down is permanent. It would be idle to attempt to predict the new developments to be expected in the future. Probably we have little idea now as to the nature and methods of the industrial sciences of the future. The important point, however, to be emphasized is that science offers at least the possibility of abolishing poverty and completely freeing mankind from the bondage of too keen an economic necessity. A certain amount of leisure time seems to be a first essential for the development of the cultural and artistic tendencies of the human personality on which we rightly place the greatest value.

Dr. Beals spoke at some length on the accomplishments of medical science during recent years, on psychology, the social sciences and on war, but lack of space prevents more than a mere mention of these subjects having been incorporated by Dr. Beals in the course of his address. In conclusion Dr. Beals showed that science, as an institution, will have a permanent and increasingly important influence on human affairs. It would appear to hold out the prospect of solving our economic problems, conquering our diseases, alleviating our mental and psychological difficulties and improving our ethical standards.

HORACE E. MOORE, *Secretary.*



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